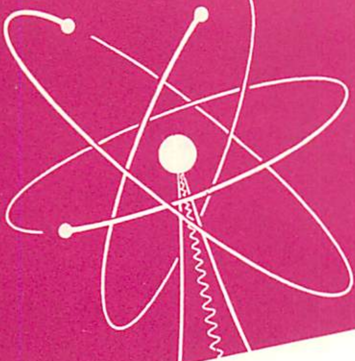
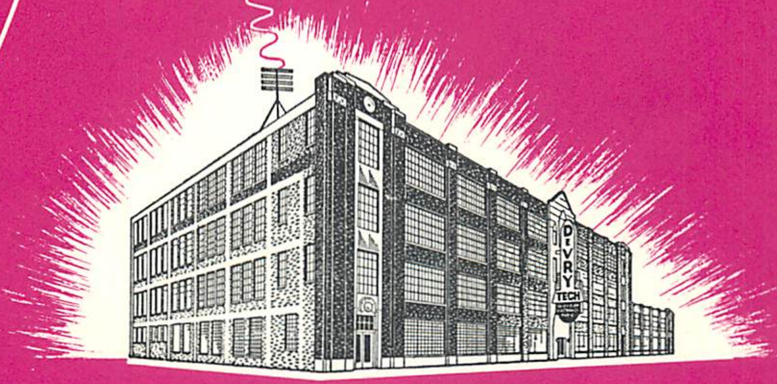


CLOSED CIRCUIT TELEVISION CAMERAS

Lesson T4E-3A



DeVRY Technical Institute

4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

T4E-3A

CLOSED CIRCUIT TELEVISION CAMERAS

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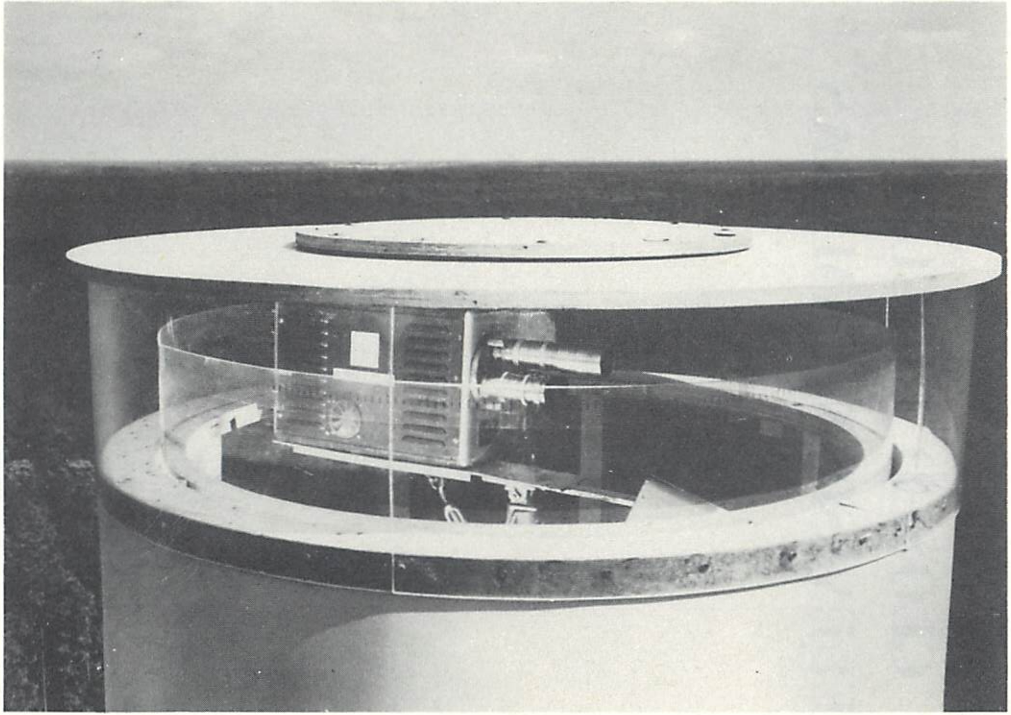

This closed circuit TV camera mounted at the top of a lookout tower, keeps a watchful eye on the surrounding forest to give immediate notification of smoke that might indicate fire.

Courtesy Raytheon Mfg. Co.

CLOSED CIRCUIT TELEVISION CAMERAS

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Television!

No word has ever been so filled with magic. Youngsters in school dream big dreams of futures in the field, as actors, as daring field cameramen, as powerful producers, or as station executives. Advertising officials fancy television as the final charge in saturating the market with their merchandise. Educators visualize magnificent advances in education and culture as television grips and molds the mentalities of our people. Idealists long for television to serve as the champion of society, eradicating interracial, international, and interreligious misunderstanding. It will fill the voids in our lives more effectively than does radio. Years of anticipation have whetted our appetites for television. Its name is magic.

—Selected

CLOSED CIRCUIT TELEVISION CAMERAS

Closed circuit television is a system which provides private rather than public communication. The desired image is transmitted over a direct cable to a selected group of viewers instead of being broadcast to the public in general. Even though industrial television is about 10 years behind the entertainment television field, it has finally taken hold and is growing fast. In fact, it may well surpass television broadcasting in investment of equipment, number of installations, and other factors as industrial television has practically unlimited potentialities.

Closed circuit television is similar to standard TV in that it uses a pick-up device, a transmitting system and a receiving device. The receiving device can be a regular television receiver or it can be a monitor designed specifically to work in conjunction with its pick-up and transmitting equipment. Basically, the circuits employed in a closed circuit system are the same as for standard television. However, some important differences exist that will be explained as the text material progresses.

There are also some striking differences in the system for closed circuit television which are an advantage over the standard system. Since it does not use electromagnetic radiations as a means of communication, it does not come under the jurisdiction of the Federal Communications Commission. Consequently, there are no limitations and restrictions imposed on the normal operation of the system. Nor is a license required to install and operate it. Depending upon the specific requirements of the system, it can be designed to handle a high definition picture in either color or black-and-white. Likewise, if cost is an important factor and the user is satisfied with a low-definition picture, the system can be designed economically and still perform a creditable job.

GENERAL USES

The uses of closed circuit television are limited only by the imagination and ingenuity of the users and manufacturers. Practically all fields of industry, medicine, government, etc., can use closed circuit television advantageously.

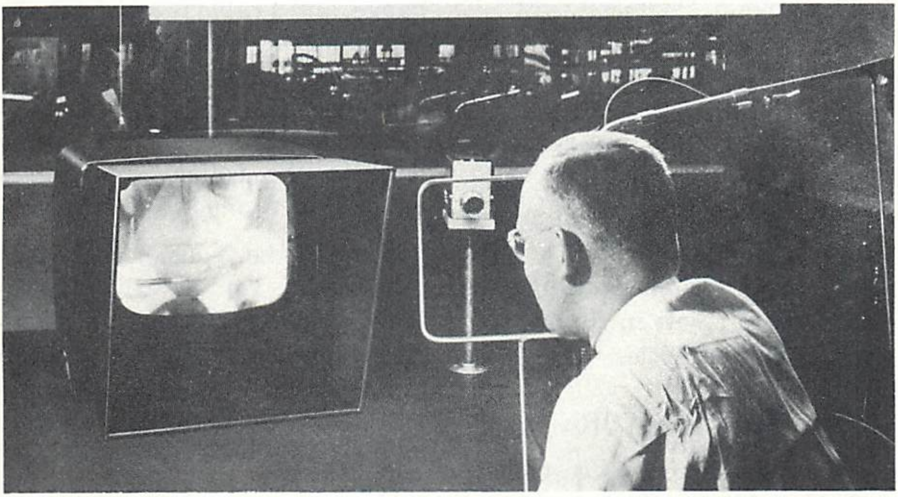
MEDICAL

Hospitals can install a camera immediately above an operating table. As many *monitors as* desired can then be used to enable interns and other doctors to observe closely the techniques employed by an expert surgeon while performing an actual operation. Naturally, this technique increases the number of personnel that can be trained and also reduces the amount of time necessary for this training.

The training of psychiatric personnel is also tremendously improved by closed circuit television. A camera is installed in a hidden place in the consultation room. Students of the subject can observe the patient's reactions as the treatment progresses. Since the patient is unaware of any observers, true reactions are obtained.

BANKS

Banks too, can find use for the seen and unseen eye of the closed circuit camera. Some banks are now using the system for signature verification. The files containing the signatures of depositors and other important documents can be stored at a point removed from where the actual transactions take place. The camera is located at the distant files and the monitor is placed at the most convenient point for the bank agent. Instant and accurate verification thus can be obtained.



At a Bulova Watch Company plant, the RCA closed circuit TV system is used for visual communication between engineering and production departments which are located in different buildings.

Courtesy Radio Corporation of America

DEPARTMENT STORES

Department stores are finding closed circuit television very effective in promoting the sale of a particular item or line of goods. The camera can be placed in a remote part of the store which is featuring a style show, a sporting goods demonstration, machinery exhibition, etc., and the monitors can be placed suitably for crowd observation. In this way, potential customers can be attracted to other parts of the store by letting them see what is taking place. This method of featuring merchandise before the maximum number of people is certain to result in increased sales.

Small, expensive items such as watches, rings and other jewelry can be safeguarded by the use of cameras and monitors. In fact, notices posted at conspicuous places announcing that such a "seeing-eye" system is being used will usually result in suppressing shop-lifting activities.

RESCUE WORK

Since the camera is responsive to infrared light which penetrates smoke and fog better than ordinary light, rescue work often can be speeded up. In a mine explosion, for example, a camera with an infrared light mounted on it can be lowered to the scene of the accident. In this way, direct observation can be made through smoke much better than could be made with the human eye, and the observers are not endangered.

INSTRUMENT OBSERVATION

In many industries, rather large boilers are used for various purposes and the gauges showing the water level in the boilers are extremely important. These water gauges practically always are attached to the boiler and many times it is quite inconvenient for any person to read the water gauge. In a situation like this, the camera is pointed directly at the gauge, and a cable is laid from the camera to a central control room in which a monitor is installed. This arrangement permits immediate observation of the water level in the boiler and insures maximum efficiency and safety.

Some of the thousands of other uses for this rapidly growing system of observation are in factories to observe the flow of parts on a production line; to observe experiments involving radioactive material or high explosives; in conjunction with a microscope, to enable more than one person to simultaneously study the objects under view; to help in controlling the flow of traffic in long, underground tunnels; to observe the pouring of molten steel; keep a constant watch at vital points on a coal conveyor; to guard plant entrances; to aid the pilot of a large ship to bring it in to the dock by having a camera mounted on the hull and the monitor located next to the steering mechanism; underwater observation of marine life or of a sunken ship to help determine the best way to perform salvage operations.

These are just a few of the many, many uses to which closed circuit television can be put. Once again it should be stressed that the possibilities are so limitless that there is no way of forecasting just how large this relatively new observation industry can become. There is no doubt, however, that closed circuit television will shortly become one of the major industries of this nation.

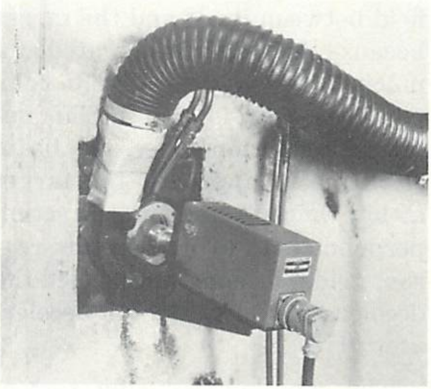
VIDICON CAMERA TUBE

The heart of any closed circuit television system is the camera tube. One of the most common tubes used in present day cameras is the **vidicon.** Its small size —6¼ inches in length and one inch in diameter — and relative simplicity, in comparison with the larger IMAGE ORTHICON used in TV broadcast cameras, makes it extremely adaptable for use in small, compact cameras which are light in weight. The simplicity of construction of the vidicon also results in lower cost of manufacture and operation.

Principle of Operation

Figure 1 is a drawing of the vidicon pickup tube to illustrate operational functions. The structural arrangement consists of the signal electrode which is a transparent conducting film on the inner surface of the glass faceplate and a light-sensitive element consisting of a thin layer of photoconductive material deposited on the scanning side.

Located adjacent to the photoconductive layer, grid 4 is a fine mesh screen which is connected internally to grid 3 and is operated at the same positive voltage (200 to 300 volts) in respect to the cathode or ground. Grid 3 is a focusing electrode which helps to focus the electron beam on the photoconductive signal electrode target.



The industrial camera keeps a constant watch on the fire box in a large electric generating plant.

Courtesy Radio Corporation of America

Accelerator grid 2 is usually operated at about 300 volts positive. In operation, control grid 1 causes beam current cutoff at

−45 to −100 volts. The electron gun is conventional and employs a cathode and a 6.3 volt heater. Usually, the cathode is connected to ground or B−.

During operation, it is necessary that the scanning beam strike the photo-conductive layer at right angles, regardless of the angle of approach. Otherwise, the beam has a tendency to spread or smear and produces a picture with poor definition. Grid 4 serves to provide a uniform decelerating field between itself and the target because the target is operated at a much lower voltage (20-50 volts positive) than is grid 4. This decelerating action causes the beam electrons to approach the target at low velocity and in a direction perpendicular to it. For this reason, grid 4 is sometimes called the decelerating electrode or decelerator grid.

The complete focusing system is a combination of an electrostatic field created by grid 3 and a uniform magnetic field from the focusing coil which is located around the outside of the vidicon. The alignment coil causes the picture to rotate around a point in the center of the picture and usually is not a critical adjustment.

The metal flange around the front end of the tube is the signal electrode connection and the load resistor R_L is connected to this electrode. The other end of the load resistor is returned to the B+ supply. An examination of Figure 1 shows that the complete electron path is from ground to the cathode, through the scanning beam to the photoconductive target, through the load resistor to B+, and through the power supply to B− or ground.

In order to explain the operation of the vidicon camera tube, let us first consider the conditions with no light entering the camera lens. Each element of the photoconductive layer is an insulator in the dark, but conducts slightly when light strikes it. Thus, the layer is a material in which the resistance changes with changes of light. For explanation purposes, this arrangement can be thought of as a capacitor in which the "dielectric resistance" changes with the amount of light entering the camera lens. In effect, one plate is charged to the positive voltage of the signal electrode while the other plate "floats".

As the beam sweeps the target area, it deposits electrons upon the positive target surface until the surface reaches cathode voltage. The remaining beam electrons form a return beam, under the influence of the positive grids. The electrons which are deposited on the target form the signal current while the electrons in the return beam are not used. Even though a substantial charge now exists across the plates of the light sensitive element, there is little current because of the high resistance of the element. This small current is called the "dark current".

When light of some scene is focused on the light sensitive element by the lens, the transparent conducting film on the inner surface of the glass faceplate increases conduction. The actual conduction depends upon the intensity of light at the point of the film being illuminated. In turn, the lowered resistance of the conducting element at this point attracts a few electrons from the plate on the scanning side. The voltage of this plate rises toward the voltage of the target supply creating a positive potential image that corresponds with the light distribution entering the lens and striking the transparent conducting film.

As the electron beam scans the photoconductive layer on the gun side, electrons are extracted from the beam in sufficient quantities to equalize the charge that has been built up. This increased current passes through the load resistor and causes the point to which the coupling capacitor is connected to swing in the negative direction.

Since dark areas cause very little current and bright areas cause large currents, the voltage across the load resistor swings negative for highlights and positive for black areas in the scene under observation. Insofar as the polarity of the video signal is determined by the direction in which the signal swings for black areas, the output of the vidicon has positive polarity or negative picture phase.

Characteristic Curves

The **spectral sensitivity** characteristic curves of the type 6198 vidicon are illustrated in Figure 2. The dashed curve B shows that the normal response of the human eye is from 4000 to 7000 Angstrom units. The Angstrom unit is a measure of wavelength equal to 10^{-8} centimeter and is often used in conjunction with exceptionally high frequencies such as light. The highest visible frequency, or shortest wavelength (4000 Angstrom units) is violet and the lowest visible frequency, or longest wavelength (7000 Angstrom units) is red.

Curve A of Figure 2 is the spectral sensitivity when the lighting conditions simulate "daylight". Curve C illustrates the spectral sensitivity of the vidicon under common incandescent lighting conditions. Notice that the maximum response of the vidicon under "daylight" conditions is in the blue region of the color spectrum while the maximum response with common incandescent lighting is in the green-yellow region and is similar to the response of the human eye. Notice too, that the response of the vidicon, regardless of the type of lighting used, extends into both the INFRARED and ULTRAVIOLET region. This characteristic is quite important as it enables the vidicon to "see" where the human eye cannot.

Besides the vidicon, there are other types of camera tubes in use. Among these are the super iconoscope and the image dissector. Even though the principles of operation of these camera tubes is slightly different from that of the vidicon, the overall design of the complete camera system and the net results are basically the same. Therefore, this lesson does not include a separate explanation of all the various camera tubes.

THE RCA CAMERA

One of the simplest types of cameras used in present day closed circuit television systems is the RCA unit, a schematic of which is shown in Figure 3A. Because of space and design considerations, the only components in the camera are the absolutely essential ones. The power supply, deflection circuits, the necessary controls and associated circuits are all located in the **camera control unit.** This arrangement permits the assembly of a small and light camera, and enables it to be placed in the most advantageous location as adjustments are made remotely.

The DuMont "Tel-Eye" Camera is small and compact. It can be inconspicuously mounted in hard-to-get at places.

Courtesy Allen B. DuMont Laboratories, Inc.

Vidicon tube V_1 is employed as the pick-up device and operating voltages are applied to it by means of various leads in the "connector cable" leading to the camera control unit. Point "A", at the lower left in the diagram, supplies the focus and decelerating electrodes (6) with a variable voltage in the neighborhood of 200 volts. The voltage at this point is varied by the focus control in the camera control. Point "B" supplies the heater (8) with 6.3 v a-c. Point "C" applies a negative voltage to the grid 1. (2), the value of which is dependent upon the setting of the beam control in the camera control unit. Point "D" applies about 300 volts positive to grid 2 or the accelerating electrode (5).

Point "E" applies negative blanking pulses to the grid of V_{3B} which amplifies the pulses and applies them to the cathode (7) of the vidicon as positive pulses. Since positive pulses on the cathode have the same effect as negative pulses on the grid, the electron beam of the vidicon is blanked out during retrace time. Point "F" is the ground return for V_{3B} and is terminated at the ground point in the camera control to which the load resistor for the blanking pulses is connected. This precaution prevents any extraneous pick-up due to common ground connections from affecting the blanking pulses.

Point "G" applies a positive variable voltage to the signal electrode or target. This voltage is about 30 volts and is determined by the setting of the target control in the camera control unit. Point "H" at the lower right, and point "I" at the lower left apply the proper B+ voltage to tubes V_2, V_{3A}, and V_{3B}.

The output of the vidicon is developed across R_5 and coupled through C_5 to the control grid of V_2. The video output signal of the vidicon is negative picture phase and appears in the plate circuit of V_2 as an amplified positive picture phase signal. This signal is applied to the grid of cathode follower stage V_{3A}. Point "J", at the right, connects to a coaxial cable, the characteristic impedance of which is approximately 51 ohms. The load resistor for the cathode follower is located in the camera control unit and is 51 ohms in order to match the impedance of the coaxial cable. This method prevents any loss of signal—especially at the higher video frequencies—and also prevents reflections on the line which would result in ghosts.

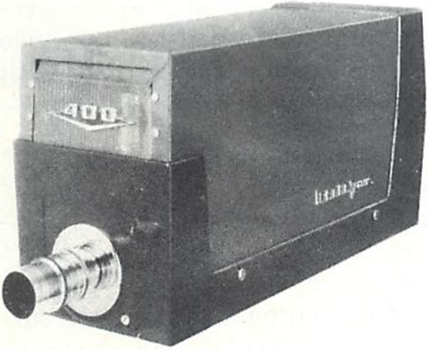
At the upper left in the diagram, points "K" and "L" provide the vertical deflection coils with a sawtooth current at 60 cps, whereas points "M" and "N" provide the horizontal deflection coils with a 15,750 cps sawtooth current.

It might appear as though the video amplifier section of this camera is inadequate in comparison to some other cameras. Its purpose, however, is merely to amplify the output of the vidicon sufficiently so that the signal can be sent by cable to the camera control without having stray noise voltages affect it too severely. The camera control unit has several additional stages of video amplification to bring the signal up to a useable level. Once again, the idea here is to keep the camera as small and compact as possible.

THE GENERAL PRECISION LABORATORY CAMERA

Figure 3B is the schematic diagram of a camera unit manufactured by General Precision Laboratory and, like the RCA unit, is designed to contain the minimum number of components which reduces the weight and size of the camera.

From pin 11 of the interconnecting plug, positive vertical blanking pulses are applied to the cathode of the camera tube (V_{101}). From pin 8 a negative voltage is applied to the vidicon grid to control the beam current. A positive voltage is obtained from pin 19 and applied to the focus electrode. Pin 20 supplies the direct voltage for the vidicon target.



The "Utilivue 400" Camera is very popular with industry as it is very rugged, and requires only a monitor to complete the camera chain. Courtesy Diamond Power Specialty Corporation

The video signal is coupled from the target of the vidicon to the input grid of the cascode amplifier (V_{102}). Pin 2 of V_{102} is at signal ground potential due to C_{107}. This arrangement causes the right half of the 6BQ7 to function as a grounded grid amplifier. Since a grounded grid amplifier does not invert the polarity of the signal applied to its cathode, the signal appears at lug 1 of V_{102} as shown. Amplified further by the pentode section of V_{103}, the signal is fed from the cathode of the triode section to the camera control unit by a coaxial cable.

Notice that the only controls on this camera are potentiometers R_{119} and R_{122} which set the amplitude and polarity of the current in the alignment coils.

When the moveable arm of R_{119} is moved up, the left hand alignment coil is placed in parallel with R_{120} and electrons flow from the black lead to the red lead. When the arm of R_{119} is moved down, the coil is placed in parallel with R_{121} and electrons flow from the red lead to the black lead.

THE DU MONT "TEL-EYE" CAMERA

Figure 4 is a block diagram of a DuMont "Tel-Eye" camera. For simplicity, the deflection circuits and the power supply have been omitted.

Applied to the vidicon are the blanking pulses which cause beam current cutoff during retrace intervals. The output of the vidicon is fed to the video amplifier section where the horizontal and vertical sync pulses are added to complete the composite video signal.

The final video amplifier has two outputs, one of *which can* be used directly to feed a monitor.

The other output is used to modulate an r-f signal that is generated by the r-f oscillator. The modulated r-f output can be fed by coaxial cable to a regular TV receiver which is tuned to the same channel as the r-f oscillator of the camera.

The partial schematic diagram of the Tel-Eye camera is shown in Figure 5.

Controls

Here too, the pick-up tube is the vidicon but in this arrangement the target, focus, and beam voltages can be adjusted at the camera or by remote controls located at a distant point. At the upper left in the diagram of Figure 5, **the target control** (R_{31}) acts as a voltage divider in conjunction with R_1 and is designed to provide from 0 to 100 volts at the junction of R_1 and R_2. This voltage is applied through R_2 and R_3 to the vidicon target.

The Focus Control (R_{32}) forms a voltage divider with R_{34} and R_{35} which varies the voltage at the focus electrode from about 140 to 220 volts. **The beam control** (R_{33}) forms a voltage divider with R_{36} and R_{37} and applies approximately -12 to -100 volts to the control grid of the vidicon. Switches S_{1A}, S_{1B} and S_{1C} are ganged to permit these voltages to be controlled remotely. When the potentiometers (TARGET, FOCUS, and BEAM) are rotated to their maximum counterclockwise positions, the switches are actuated which remove the potentiometers from their respective circuits and transfers their connections to the REMOTE CONTROL CONNECTOR jack located in the rear panel. This jack is used to connect to a remote control unit with duplicate control potentiometers.

Negative horizontal pulses are applied to the grid of the vidicon while positive vertical pulses are applied to the cathode. These pulses are obtained from the deflection circuits and are for the purpose of blanking out the vidicon electron beam during retrace time.

Video Amplifier

The video amplifier section used in this camera is considerably more elaborate than the one used in the camera previously described. The negative picture phase signal at the output of the vidicon is amplified by V_{2A} and V_{2B} and appears at the input to V_{3A} with the same polarity. While not included in the simplified tracing of the video signal, it is well to mention that the purpose of the crystal diode in the grid circuit of V_{3A} is to provide d-c restoration and minimize any hum that might be present.

The output of V_{3A} is positive picture phase and is applied to the grid of V_{3B}. Since the output of

V_{3B} is the cathode circuit, no phase inversion takes place and the signal is still positive picture phase which means that the voltage representing black is in the negative direction. At this same point—the cathode of V_{3B}—negative horizontal pulses are mixed with the video signal and the combination is applied to the grid of V_{4A}. Applied to the cathode of V_{4A} are positive vertical pulses. At this point it should be remembered that applying positive pulses to the cathode has the same effect as applying negative pulses to the grid. Therefore, in the plate circuit of V_{4A}, the horizontal and vertical sync pulses are positive in polarity. Since the video information is applied to the grid of V_{4A} with black negative, the signal appears in the plate circuit with black positive. The combined signals in the plate circuit of V_{4A} are a composite signal of negative picture phase.

This signal is amplified by V_{4B} and appears at the input of V_{5A} as positive picture phase. V_{5A}, being a cathode follower, does not invert the phase of the signal and it appears in the cathode circuit with the same polarity. The signal is fed through a 51 ohm coaxial cable to the monitor where the cable is terminated with a 51 ohm resistor to provide the proper impedance match. The amplitude of this composite signal is approximately 1.5 volts peak to peak.

In the input circuit of V_{5A}, resistors R_{25} and R_{26} form a voltage divider across the −130 v portion of the power supply. R_{25} is made considerably larger than R_{26} so that a small negative voltage is applied through R_{24} to the grid of V_{5A} to provide the necessary bias voltage for this stage.

R-F Oscillator and Modulator

The complete composite video signal also is taken from the plate of V_{5A} and fed through C_{14} to the grid of V_{8A}. Before continuing the explanation of V_{8A}, consider the circuit action of V_{8B}. The cathode of V_{8B} is connected to a tap on coil L_9. This arrangement provides a conventional Hartley oscillator with L_9 and C_{18} forming the tank circuit and the combination of C_{19} and R_{39} providing grid leak bias. Coil L_9 is adjustable so that it can be tuned to resonate at 61.25 mc. (Channel #3) or 67.25 mc. (Channel #4). The r-f output of the oscillator is coupled through C_{21} to the cathode of V_{8A}.

With the r-f signal applied to its cathode and the composite video signal applied to its grid, V_{8A} functions as a modulator. The signal output in the plate circuit is modulated r-f which is fed through C_{22} to the r-f output jack. This signal can then be fed by coaxial cable to the antenna of any ordinary television receiver which functions as a monitor. When properly terminated, the output of the modulated r-f signal is approximately 1 millivolt.

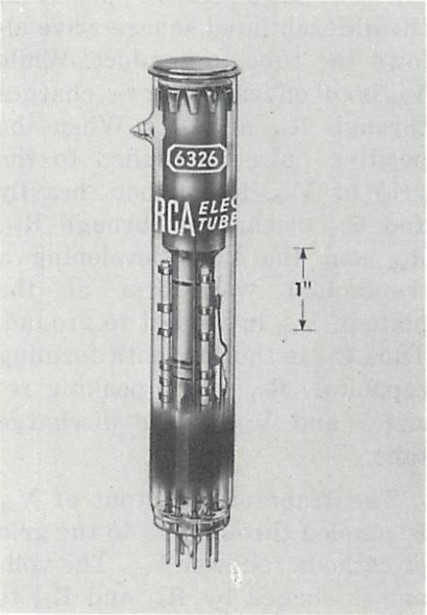
It should be noticed that resistor R_{30} in the cathode of V_{5A} has a value of 4300 ohms. If the modulated r-f output of the camera is being used to feed a regular TV receiver, it will be necessary to terminate the video output jack with a 51 ohm dummy load resistor. Without this dummy load resistor, R_{30} would bias V_{5A} too much and result in improper operating conditions.

The camera also contains the power supply and deflection circuits of Figure 6. These circuits differ enough from those studied in previous lessons to warrant a brief explanation.

Power Supply

As shown near the center of the diagram, one half of a 6AL5 (V_9) is employed as a half wave rectifier to provide the +240 volts output while the other half provides the −130 volts output. The current requirement of each voltage output is quite small, making possible the use of the 6AL5 as a rectifier.

Four selenium rectifiers are connected as a full wave bridge to provide the +127 volts output and supplies the greatest part of the current required by the various camera circuits. This arrangement permits full wave rectification at half of the transformer voltage ordinarily required and eliminates the necessity for a center-tapped transformer.



One of the newer Vidicon tubes, the 6326. Its small size can be determined by the scale representing one inch.
Courtesy Radio Corporation of America

Vertical Deflection

At the upper right, voltage regulator VR_1 clips off the positive and negative peaks of the 60-cycle sine wave applied to it through R_{15}. The resulting square wave is differentiated by C_9 and R_{18} with the resultant pulses developed across R_{18}.

VR_2 maintains a regulated voltage of about −30 volts at the junction of R_{16}-R_{17} in respect to ground. This voltage is divided between R_{16} and R_{18} to provide approximately -3 volts d-c as the bias on the grid of V_{6B}. This bias is sufficient to hold V_{6B} at cutoff until the large positive pulse from the differentiated square wave allows the tube to conduct. While V_{6B} is cut off, capacitor C_{11} charges through R_{21} and R_{19}. When the positive pulse is applied to the grid of V_{6B}, it conducts heavily and C_{11} discharges through R_{21}, R_{20} and the tube developing a trapezoidal wave-form at the plate of V_{6B} in respect to ground. Thus C_{11} is the sawtooth forming capacitor, R_{21} is the peaking resistor and V_{6B} is the discharge tube.

The trapezoidal output of V_{6B} is coupled through C_{12} to the grid of cathode follower V_{5B}. The voltage is shaped by R_{22} and R_{24} to produce a sawtooth current in the vertical deflection coils. R_{27} varies the d-c voltage across the coils and is the vertical centering control.

A positive pulse taken from the cathode of V_{6B} is used as vertical blanking at the cathode of the vidicon and is added to the video signal as the vertical sync pulse.

Horizontal Deflection

Checking the circuit at the left in Figure 6, deflection voltages for horizontal scanning are derived from the cathode-coupled multivibrator circuits of V_{6A} and V_7. The frequency of the oscillator is determined by variable resistor R_1, resistor R_{2A} and capacitor C_{1B}. Tuned circuit L_1 and C_{1A} stabilizes the oscillator at a frequency of 15,750 cps, while the feedback voltage necessary to sustain oscillations is provided by C_4 which couples the cathodes together.

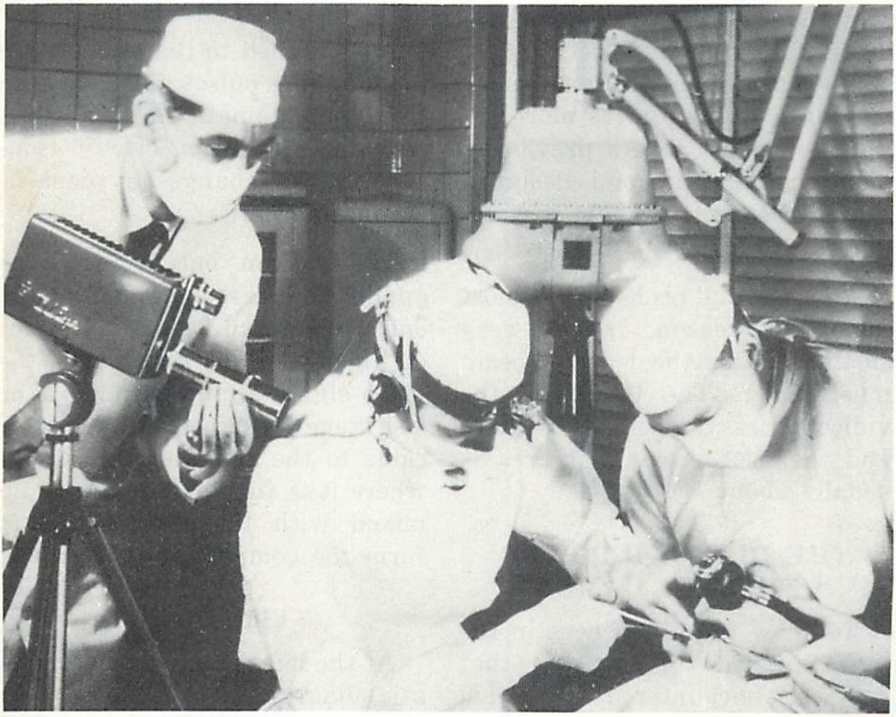
At the start of the sweep, V_{6A} is cut off by a negative voltage across C_{1B}, which permits C_2 to charge towards B+ and develop the sweep voltage. When C_{1B} has discharged sufficiently through R_{2B}, R_{2A} and R_1, V_{6A} conducts heavily which permits C_2 to discharge. The conduction of V_{6A} also applies a negative voltage to the grid of cathode follower V_7. This results in a negative pulse at the cathode of V_7 which is coupled by C_4 to the cathode of V_{6A} and the horizontal deflection coils. A negative pulse at the cathode is effectively a positive pulse at the grid and causes grid current in V_{6A}. This grid current charges the ungrounded plate of C_{1B} negative and once again cuts off V_{6A}.

The negative pulses at the cathode of V_7 are coupled through C_6 to the grid of the vidicon tube to blank out the electron beam during the horizontal return trace. Negative pulses with a smaller peak to peak amplitude are obtained by connecting to the junction of R_{12} and R_{13} and are added to the video information (at the cathode of tube V_{3B} in Figure 5) as sync pulses.

Since this camera does not use a timing generator to control the sweep voltages, the vertical scanning circuits are synchronized with the power line but the horizontal deflection circuits are free-running. If it is desired to use an external sync generator to control the horizontal oscillator, a negative pulse can be applied at point "A" on the diagram. In this case, the external sync generator should be synchronized with the same power line that is being used for the camera.

Most of the direct current through V_7 passes through the focus coil and in conjunction with the variable voltage applied to the focus electrode in the vidicon, acts to focus the electron beam at the target. C_8 and R_{14} act as a filter network to prevent variations in the V_7 plate current from affecting the beam focus.

A point of considerable interest is that the deflection circuits



RCA "TV EYE" televising closed circuit picture of oral operation at Kansas City Dental School.
Courtesy Radio Corporation of America

can obtain sufficient energy from relatively low current tubes such as one section of a 12AT7. In a conventional television receiver, it is necessary to use a tube that is capable of handling large currents. For example, the most common horizontal output tubes in TV receivers are the 6BQ6, 6BG6 and 6CD6.

One of the most important reasons why low power tubes can be used in vidicon deflection circuits is due to the fact that the electrons striking the target are traveling at a much lower speed than the electrons striking the fluorescent material of a television CRT. Since a fast moving electron possesses more energy than a slow moving one, it requires more energy to deflect it. As previously mentioned, the vidicon is designed so that the electron beam does not travel at a high rate of speed.

Another, and probably the most important reason, is the very small area that the deflected beam must cover. The target of the vidicon is less than one inch square and the useful scanning area is usually about ½″ by ⅜″.

THE DIAMOND POWER "UTILIVUE" CAMERA

To show the differences in the various types of cameras that may be encountered in actual practice, Figure 7 is the block diagram of a camera that is manufactured by the Diamond Power Specialty Corporation of Lancaster, Ohio, available under the trade name of "Utilivue".

This unit contains the vidicon, the video preamplifiers, a blanking amplifier, an automatic target control circuit and a vidicon protection circuit to prevent damage to the vidicon in the event of failure of either of the deflection circuits.

Voltages derived from the horizontal and vertical scanning circuits are applied to the vidicon protection circuit which controls the anode voltage of the vidicon.

Also applied to the vidicon are the blanking pulses and a voltage from the automatic target control circuits. The latter circuit compensates for changes in scene illumination.

The vidicon output signal is applied to a cascode amplifier the output of which is fed to a series of video amplifiers. Finally, the video signal at the output of the last stage is connected by coaxial cable to the camera control unit where it is further amplified and mixed with the sync pulses to form the composite video signal.

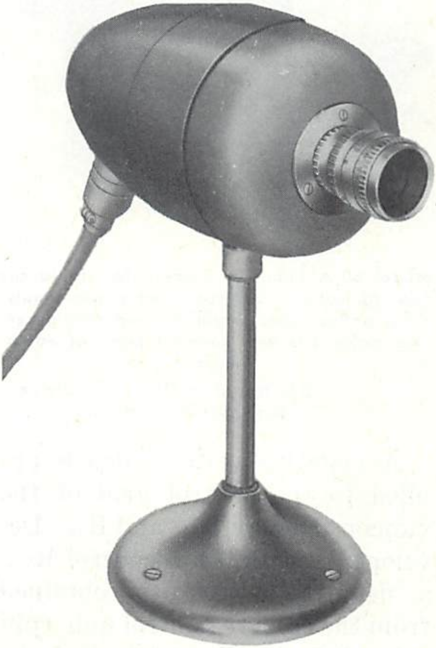
Video Amps

At the left center in the schematic diagram of the camera in Figure 8, the video signal is taken from the vidicon (V_{301}) target connecter and applied to the input of the cascoded amplifier consisting of V_{302} and V_{303}. Triodes V_{302A} and V_{302B} are connected in parallel as are V_{303A} and V_{303B}. The parallel connection of the tubes permits a greater gain to be realized than can be obtained with a single triode and the low noise characteristics of a triode are maintained. The four 120 ohm resistors located in the plate and grid circuits of V_{303} are parasitic suppressors and help to prevent any unwanted oscillations from occurring.

It should be noticed that C_{304} places the grids of V_{303} at ground as far as the signal is concerned. Thus, V_{303} functions as a grounded grid amplier. The signal is then amplified by V_{304}, V_{305} and V_{306A} which are connected as conventional video amplifiers. The triode sections of V_{304} and V_{305} are placed between the pentode sections as the input and output capacitances of the tubes are such that this arrangement provides better peaking of the high frequencies.

A negatively polarized video signal (negative picture phase) of approximately .05 volts peak to peak amplitude is finally taken from the plate circuit of V_{306A} and fed through the interconnecting cable (pin #1 of J_{301}) to the main video amplifier located in the control unit used with this camera.

Even though not indicated on the diagram, the peaking coils are adjustable and are pre-set at the factory along with the high peaker (C_{315}) so that the band-pass of the video amplifier is approximately 6 megacycles. It is usually not a good policy to change the setting of these adjustments unless it is absolutely necessary.



Even though this might appear to be a microphone, it is a closed circuit TV camera particularly adaptable for desk mounting.

Courtesy General Precision Laboratories, Inc.

Positive blanking pulses—both horizontal and vertical—are obtained from the Camera Control unit (pin #8 of J_{301}) and fed to the grid of blanking amplifier

V_{306B}. Negative pulses appear in the plate circuit and are applied through C_{332} to the control grid of the vidicon to cause beam current cutoff during retrace time.

Model 60-A Industrial Camera for closed circuit applications. Self-contained power supply, video pickup tube, amplifiers, and sync generator make it a very compact piece of equipment.

Courtesy Dage Television Division,
Thompson Products, Inc.

A negative voltage also is applied to the control grid of the vidicon through R_{356} and R_{357}. Developed across beam control R_{358}, a negative voltage is obtained from the camera control unit (pin #13 of J_{301}). The setting of the beam control determines the bias voltage on the grid of the vidicon and controls the density of the electron beam.

Automatic Target Control

It is a characteristic of the vidicon that the target voltage is very critical and must be adjusted as the scene illumination changes. Any misadjustment of the target control will result in a washed out or very poor picture. In order to compensate automatically for changes in scene illumination, AN AUTOMATIC TARGET CONTROL circuit was incorporated in the camera. This arrangement permits a usable picture over a fairly wide range of scene illumination without the need for constantly adjusting the target control.

To accomplish this automatic feature, the video signal is taken from the cathode of V_{305B} and fed through C_{326} to the grid of V_{308B}. Due to the 100k plate load (R_{345}), the signal is amplified considerably and fed into a peak rectifying circuit consisting of CR_{302} and CR_{303}. The output is filtered and fed to the grid of V_{308A} which functions as a d-c amplifier. This tube obtains its B+plate voltage from the center tap of the target control (R_{342}) through a 56k ohm plate load. The target of the vidicon is then connected through R_{339} and R_{340} to the plate of V_{308A}.

To explain the operation of the circuit, assume that the light level of the scene being viewed is increased. This will cause the signal output of the vidicon to increase. Subsequent amplification by the video amplifiers will result in a larger video signal at the cathode of V_{305B}. Carried to the grid of V_{308B}, this action gives a greater signal at the plate of V_{308B} and causes the output of the peak rectifying circuit to apply a more positive voltage to the grid of V_{308A}. The resultant increase of plate current in V_{308A} causes a greater voltage drop across R_{341} and R_{342} which reduces the plate voltage of the tube. Since the plate voltage of V_{308A} is also the target voltage, this reduction of target voltage causes the output of the vidicon to go down and compensates for the increased light level.

When the light level on a scene reduces, all effects are opposite and results in an increase of target voltage.

Vidicon Protection Circuit

If either of the deflection circuits should cease functioning, the remaining deflection circuit would cause the beam of the vidicon to trace a straight line on the surface of the target. This circuit failure would cause a "burn-in" on the target and necessitate replacement of the vidicon tube.

To protect the vidicon from this type of damage, a VIDICON PROTECTION CIRCUIT has been added to the camera. The circuitry consists of two triodes (V_{307A} and V_{307B}) cathode coupled by a common resistor (R_{361}). Applied to the grid of V_{307B} is a part of the negative voltage obtained from the horizontal scanning circuits in the camera control unit (pin #13 of J_{301}). Also applied to the grid is a part of the B+ voltage. The divider network of R_{351}, R_{354} and R_{352} have been chosen so that V_{307B} conducts normally when the horizontal deflection circuits are functioning properly.

A positive pulse is obtained from the vertical deflection circuits in the camera control (pin #16 of J_{301}) and rectified by a germanium diode (CR_{304}). The output of the rectifier is filtered and applied as a positive direct voltage to the grid of V_{307A} which counteracts the voltage on its cathode and permits the tube to conduct normally. In the plate circuit of V_{307A} is a relay (RY-301) which has its normally open contacts in the anode circuit of the vidicon. When the camera is operating properly V_{307A} conducts normally, and the relay is sufficiently energized to keep the contacts closed. Over-all then, the components in the protection circuit have been selected so that V_{307A} conducts normally when both deflection systems are functioning.

If there should be a failure in the horizontal sweep circuits, the negative voltage applied through R_{354} to the grid of V_{307B} will be lost and the grid will go more positive. This causes an increase in conduction in V_{307B} with a resultant increase in the positive voltage at the cathodes of both tubes. The increase in bias on V_{307A} cuts the tube off and de-energizes the relay in its plate circuit. The contacts open and place the anode of the vidicon at ground potential which, in turn, cuts off the vidicon beam.

If there should be a failure in the vertical deflection circuits, there will be no positive pulse applied to CR_{304}. The grid of V_{307A} will become less positive and it will be biased to cutoff due to the normal plate current of V_{307B} causing a voltage drop across the common cathode resistor R_{361}. With V_{307A} cutoff, the relay in its plate circuit is de-energized and the contacts open placing the anode of the vidicon at ground potential.

Optical Focus

Optical focus is adjusted in conjunction with electrical focus for best picture quality. The position of the lens assembly is fixed and optical focus is accomplished by moving the vidicon on its carriage to position the photocathode with

Employees at RCA plant learn how to assemble components by observing monitor reproduction of correct procedure.

Courtesy Radio Corporation of America

respect to the lens. Focus motor M_{302} is used for this purpose. Current through the focus coil is fixed and electrical focus is accomplished by varying R_{335} which in turn varies the voltage on the focusing electrode in the vidicon.

Near the center of the diagram, horizontal frequency control L_{313} is a variable inductance which is connected to the grid of the horizontal oscillator in the camera control (through pins 7 and 15 of J_{301}) and varies the frequency of the oscillator by varying the grid load impedance.

CONTROLS

Optical Focus

In most closed circuit TV cameras, the position of the lens or lenses is fixed and optical focus is accomplished by moving the camera tube forward or backward on its carriage to position the target or photocathode with respect to the lens.

Electrical Focus

Electrical focus is adjusted in conjunction with the optical focus by passing a fixed direct current through the focus coil and applying a variable direct voltage to the focus electrode.

Target

The target control varies the direct voltage on the target or signal electrode. This voltage is adjusted for maximum contrast consistent with the best picture detail and the least amount of shading, and determines the signal current that is obtainable.

The minimum possible target voltage should be used. An increase in target voltage increases the sensitivity of the vidicon but may result in an image being permanently "burned-in" if excessive target voltage is used. The most desirable picture is obtained when maximum light and minimum target voltage are used.

Beam Current

The beam current control adjusts the bias voltage on the control grid of the vidicon which, in turn, determines the density of the electron beam. With the control set for maximum negative bias, the electron beam is cut off and no picture is obtained. As the bias is reduced, the picture is resolved with the brightest areas coming in last. The control should be set at the point where all picture highlights have the best detail. Reducing the voltage further causes the scanning spot to become too large and causes a reduction in picture resolution.

Alignment Control

The alignment control is usually a variable resistor in parallel with the alignment coil and determines direct current through the coil. This control is not critical and may not be found on all cameras.

Centering

The horizontal and vertical controls are tapped potentiometers which vary the d-c through the deflection coils. Due to the physical construction of the focus coil and deflection coils, electrical centering is always used rather than mechanical centering as is often used with regular TV receivers.

Horizontal Frequency

The horizontal frequency control is either a variable inductance, a variable capacitance, or a variable resistance. It serves the same function in the camera as it does in a TV receiver—to control the free-running frequency of the horizontal oscillator.

Width and Horizontal Linearity

Generally, width and horizontal linearity controls are included in the assembly. These two controls are used to control the amplitude and shape of the sawtooth current through the windings of the horizontal deflection coils. They are adjusted in the same manner as their namesakes in a TV receiver.

Height and Vertical Linearity

In addition, height and vertical linearity controls are used to determine the amplitude and shape of the sawtooth current through the vertical windings of the deflection yoke. Usually, they are potentiometers that vary the amplitude of the trapezoidal waveform applied to the grid of the vertical output amplifier (height) and the bias on the same stage (linearity).

Up to this point, the circuits that are generally associated with the camera have been explained. However, mention has been made of the camera control unit and the monitor that may be used with the camera. In the following lessons the camera control unit, the monitor and accessory equipment will be covered in greater detail. Some suggestions concerning maintenance of the equipment also will be included.

* * *

IMPORTANT DEFINITIONS

ANGSTROM UNIT—A measure of wavelength commonly used when referring to light frequencies. An Angstrom Unit is equal to 1×10^{-8} centimeter.

AUTOMATIC TARGET CONTROL—A circuit which automatically varies the direct voltage on the target to compensate for changes in the amount of illumination on the scene being viewed.

BEAM CONTROL—A potentiometer used to control the amount of bias on the control grid of the camera tube.

CAMERA CONTROL UNIT—Equipment used in conjunction with a camera. It contains most of the controls, the power supply, the sync generator and other circuits.

DECELERATING ELECTRODE—The electrode in a vidicon through which the beam electrons pass just before they strike the target. The large difference in potential between the two elements causes the beam to slow down or decelerate.

HIGH PEAKER—A variable capacitor connected between two stages used as the video pre-amplifier in a camera. It is used to compensate for the reduction of high frequency signal voltages inherent in most circuits.

PRE-AMPLIFIER—One or more video amplifiers that are contained in the Camera Unit. Its function is to amplify the video signal to a level that will permit it to be cabled to the control unit without being adversely affected by noise voltages.

SPECTRAL SENSITIVITY—This term usually is applied to television camera tubes and is a measure of the ability of the tube to respond to the various frequencies of light.

TARGET—A photoconductive signal electrode in a vidicon pick-up tube. The conduction of the target is directly proportional to the amount of light falling upon it.

IMPORTANT DEFINITIONS—(Cont'd)

TARGET CONTROL—A potentiometer used to control the direct voltage applied to the target, or signal electrode of the vidicon camera tube.

VIDICON—A pickup tube for television cameras. Due to its small size, good sensitivity and low cost it has become the most common pickup tube in present day industrial cameras.

VIDICON PROTECTION CIRCUIT—A circuit used to prevent the vidicon from conducting if one or both of the sweep circuits cease functioning. It automatically removes the vidicon anode voltage which cuts off the electron beam.

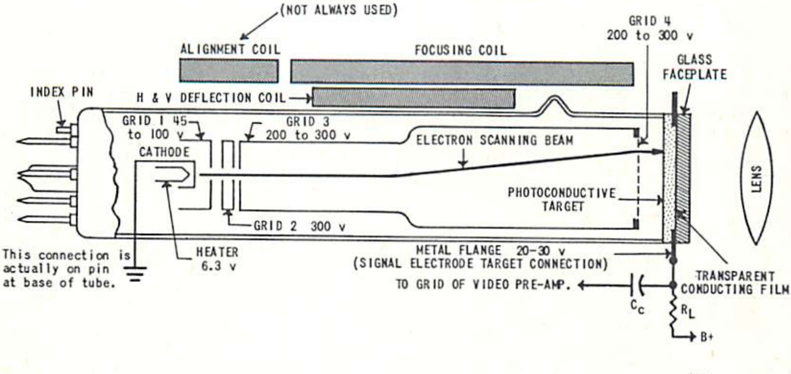


FIGURE 1

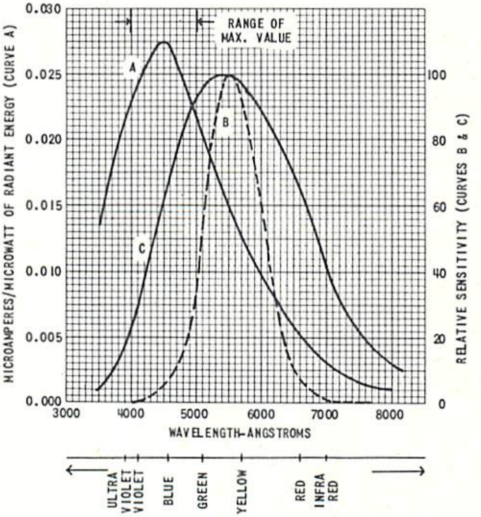
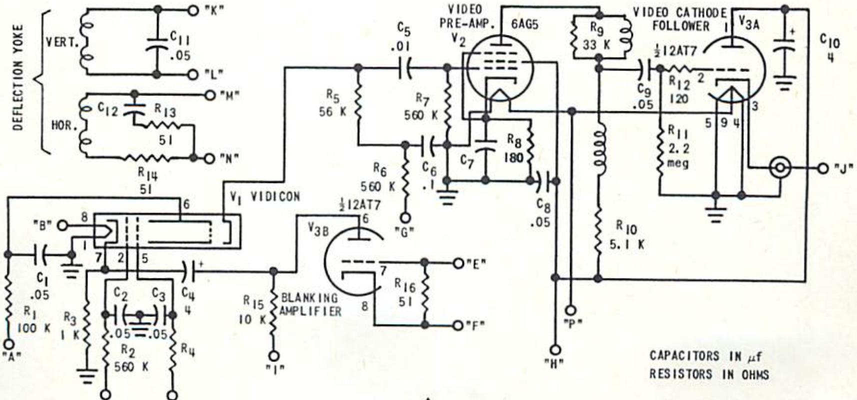
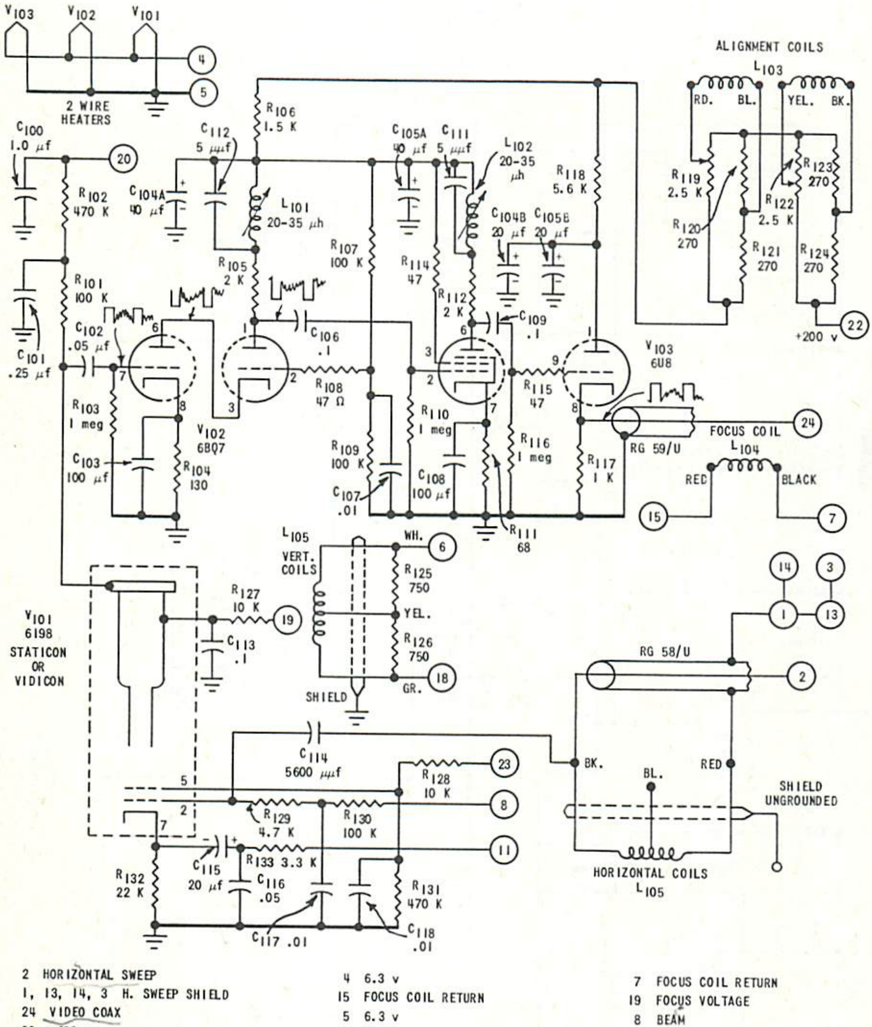


FIGURE 2



A

FIGURE 3



2 HORIZONTAL SWEEP
1, 13, 14, 3 H. SWEEP SHIELD
24 VIDEO COAX
23 +300 v
22 +200 v

4 6.3 v
15 FOCUS COIL RETURN
5 6.3 v
16 SPARE
6, 18 VERTICAL SWEEP

7 FOCUS COIL RETURN
19 FOCUS VOLTAGE
8 BEAM
20 TARGET
9 GROUND
11 VERTICAL BLANKING

B

FIGURE 3

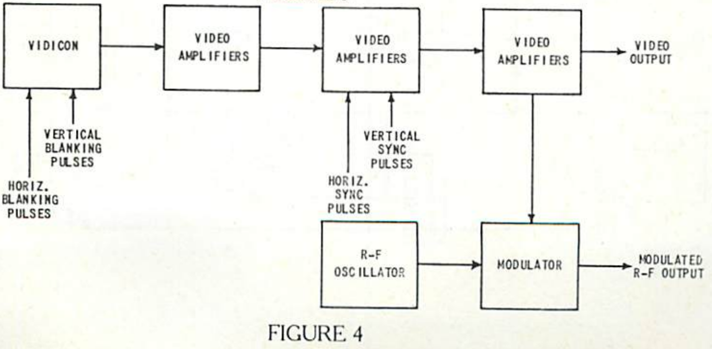


FIGURE 4

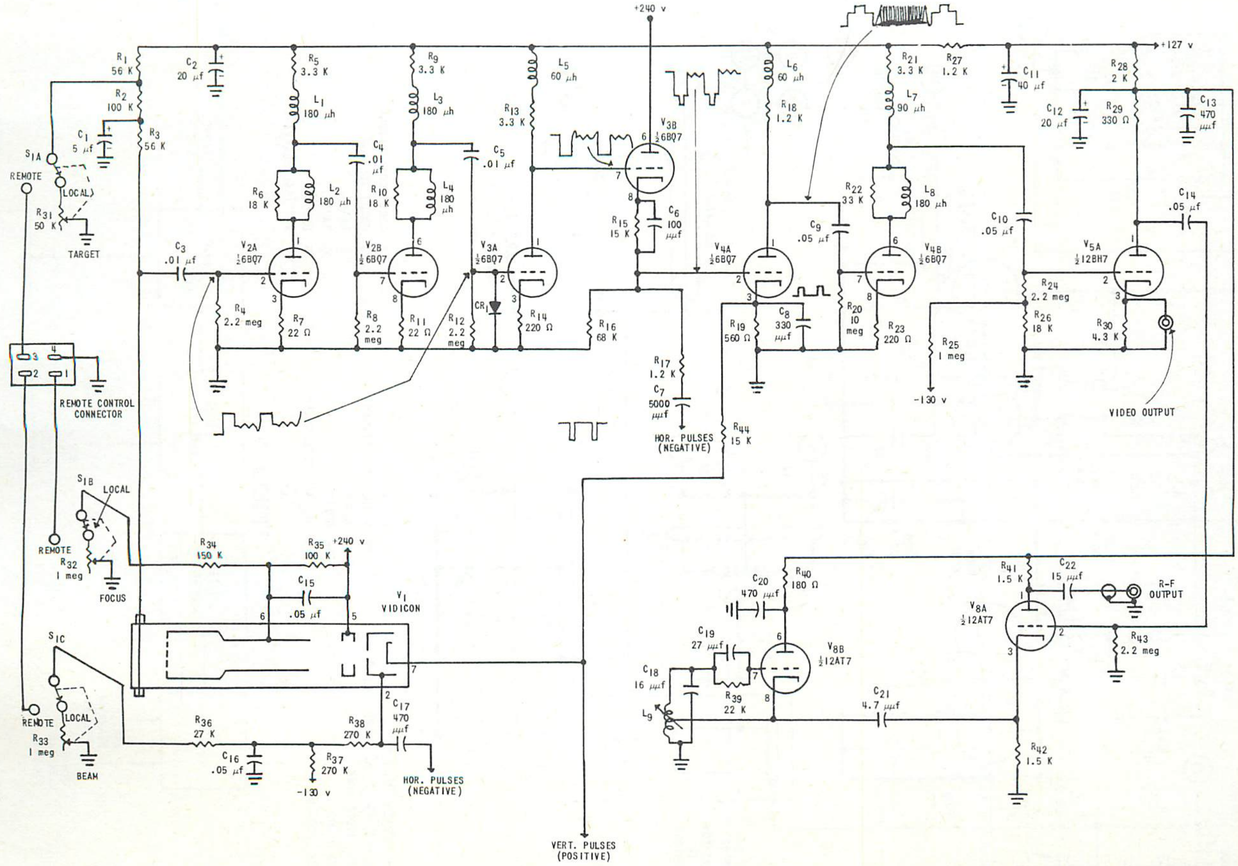
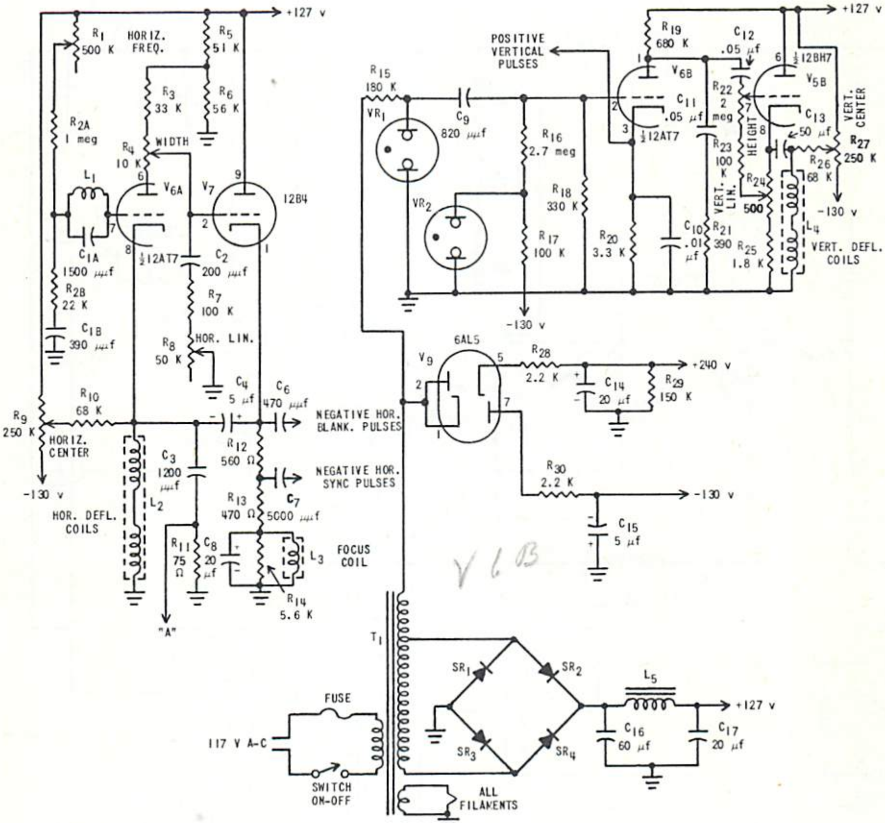
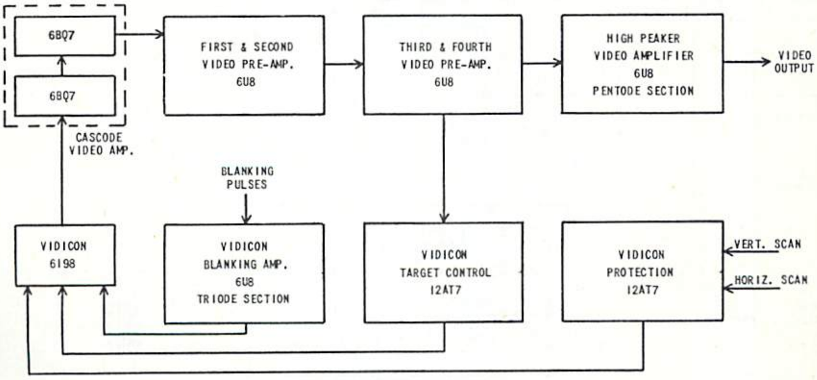

+240 v
+127 v
R1 56 K
R2 100 K
R3 56 K
C1 5 μf
C2 20 μf
R5 3.3 K
L1 180 μh
C4 .01 μf
R6 18 K
L2 180 μh
R9 3.3 K
L3 180 μh
C5 .01 μf
R10 18 K
L4 180 μh
R13 3.3 K
L5 60 μh
V3B ½6BQ7
C6 100 μμf
R15 15 K
L6 60 μh
R18 1.2 K
R21 3.3 K
L7 90 μh
R27 1.2 K
C11 40 μf
R28 2 K
C12 20 μf
R29 330 Ω
C13 470 μμf
R22 33 K
L8 180 μh
C9 .05 μf
C10 .05 μf
C14 .05 μf
S1A
REMOTE
LOCAL
R31 50 K
TARGET
C3 .01 μf
V2A ½6BQ7
R4 2.2 meg
R7 22 Ω
V2B ½6BQ7
R8 2.2 meg
R11 22 Ω
V3A ½6BQ7
R12 2.2 meg
CR1
R14 220 Ω
R16 68 K
R17 1.2 K
C7 5000 μμf
HOR. PULSES (NEGATIVE)
V4A ½6BQ7
R19 560 Ω
C8 330 μμf
R20 10 meg
V4B ½6BQ7
R23 220 Ω
R24 2.2 meg
R25 1 meg
-130 v
R26 18 K
V5A ½12BH7
R30 4.3 K
VIDEO OUTPUT
R44 15 K
REMOTE CONTROL CONNECTOR
S1B
LOCAL
REMOTE
R32 1 meg
FOCUS
R34 150 K
R35 100 K
+240 v
C15 .05 μf
V1 VIDICON
S1C
REMOTE
LOCAL
R33 1 meg
BEAM
R36 27 K
C16 .05 μf
R37 270 K
-130 v
R38 270 K
C17 470 μμf
HOR. PULSES (NEGATIVE)
VERT. PULSES (POSITIVE)
R40 180 Ω
C20 470 μμf
C19 27 μμf
C18 16 μμf
L9
R39 22 K
V8B ½12AT7
C21 4.7 μμf
R41 1.5 K
C22 15 μμf
R-F OUTPUT
V8A ½12AT7
R43 2.2 meg
R42 1.5 K

FIGURE 5



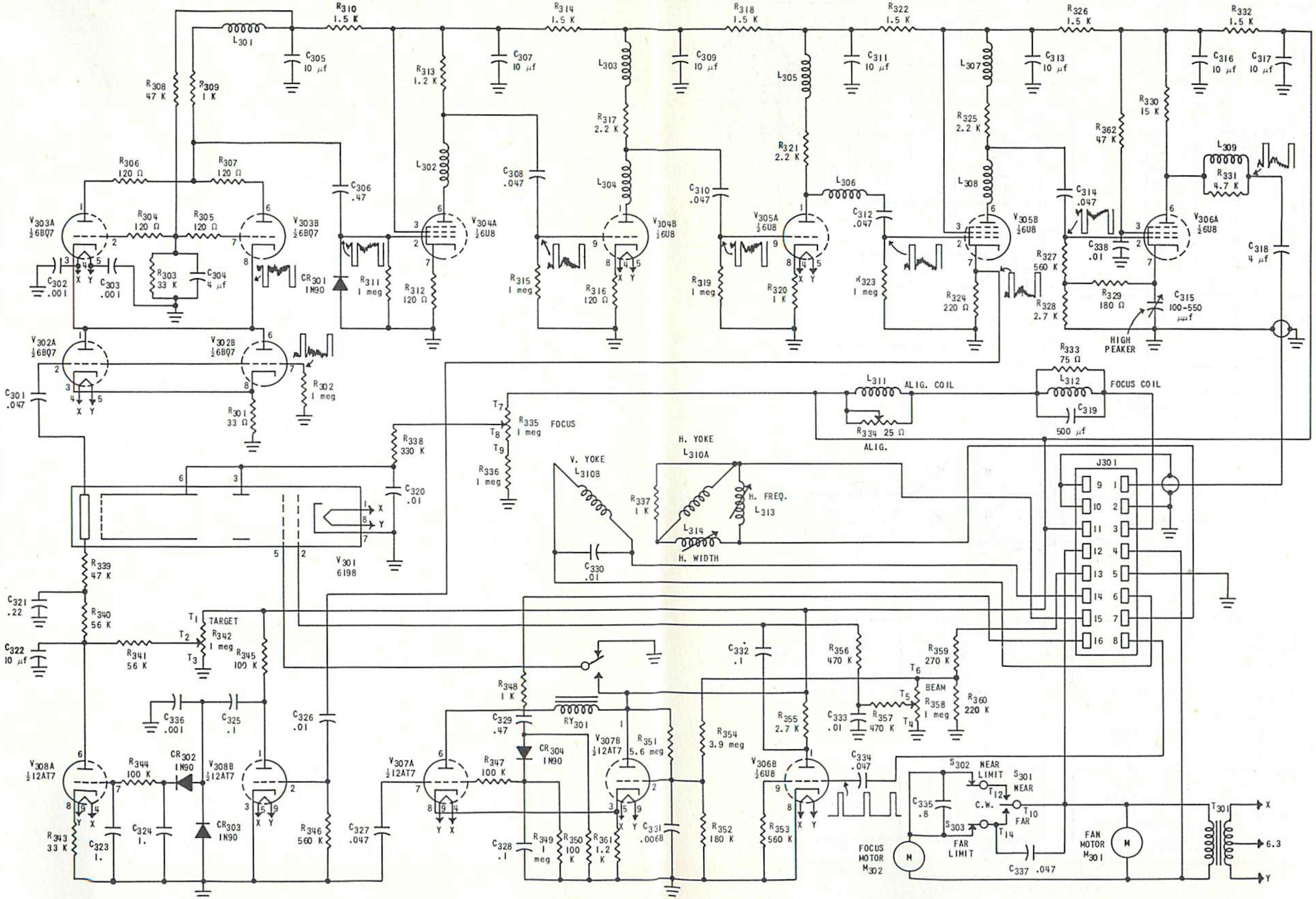
V 6 B

FIGURE 6


6BQ7
6BQ7
CASCODE VIDEO AMP.
FIRST & SECOND VIDEO PRE-AMP. 6U8
THIRD & FOURTH VIDEO PRE-AMP. 6U8
HIGH PEAKER VIDEO AMPLIFIER 6U8 PENTODE SECTION
VIDEO OUTPUT
BLANKING PULSES
VIDICON 6198
VIDICON BLANKING AMP. 6U8 TRIODE SECTION
VIDICON TARGET CONTROL 12AT7
VIDICON PROTECTION 12AT7
VERT. SCAN
HORIZ. SCAN

BLOCK DIAGRAM OF "UTILIVUE" CAMERA

FIGURE 7



ALL CAPACITORS IN µf, UNLESS OTHERWISE SPECIFIED

T4E-3

FIGURE 8

FROM OUR *Director's* NOTEBOOK

ON GETTING ADDED BUSINESS

When you are called to a customer's home to service a TV receiver, don't forget to ask if he has a radio which needs service.

The power of suggestion is great. Bring the radio tactfully to the customer's attention and, having just had his TV set properly repaired, he will be more apt to have the defective radio serviced too.

The casual question, "How are your radios operating?" may serve to recall a buzzing radio. The cost of traveling to and from the home already is paid for by the TV repair job, so the radio service is just added profit.

Thus, a "planted" reference to a radio—coming after a **good** TV repair job—can tap another source of income you now may be missing.

Yours for success,

W. C. De Vry
DIRECTOR

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